MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2022/2023

DME5106 – Fluid Mechanics

(Diploma in Mechanical Engineering)

10 JULY 2023
2.30 p.m. – 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 5 pages including the cover page with 4 Questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1 (25 marks)

A 3-m-wide, 8-m-high rectangular gate is located at the end of a rectangular passage that is connected to a large open tank filled with water as shown in **Figure Q1**. The gate is hinged at its bottom and held closed by a horizontal force, F_H, located at the center of the gate. The maximum value for F_H is 4000 kN.

(a) Determine the maximum water depth, h, above the center of the gate that can exist without the gate opening. [12 marks]

(b) Is the answer the same if the gate is hinged at the top? If no, find the new answer. [9 marks]

(c) Which answer in (a) and (b) is suitable for design consideration. Explain your answer. [4 marks]

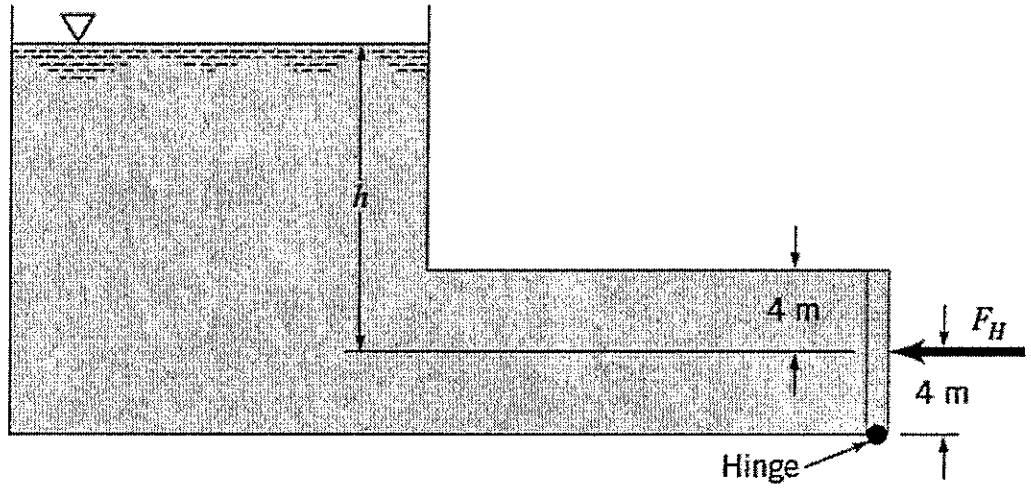
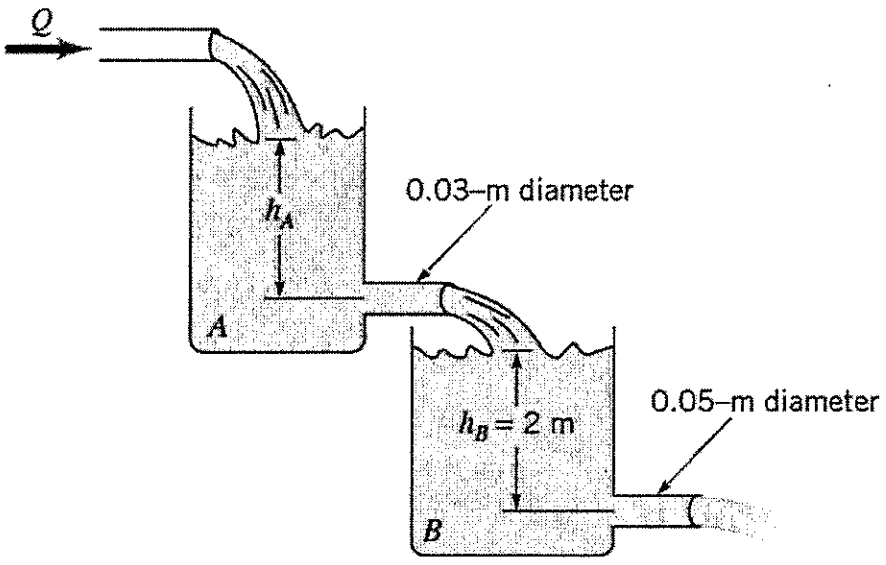


Figure Q1

Continued ...

Question 2 (25 marks)

(a) Water flows steadily through the large tanks shown in **Figure Q2a.** Determine
(i) the velocities of both outlets, [10 marks]
(ii) the flowrate of the water, [3 marks]
(iii) the water depth, h_A, [3 marks]



(b) Air flows steadily between two cross sections in a long, straight section of 0.1-m-inside-diameter pipe. The static temperature and pressure at each section are indicated in **Figure Q2b**. If the average air velocity at section (1) is 200 m/s, determine the average air velocity at section (2).

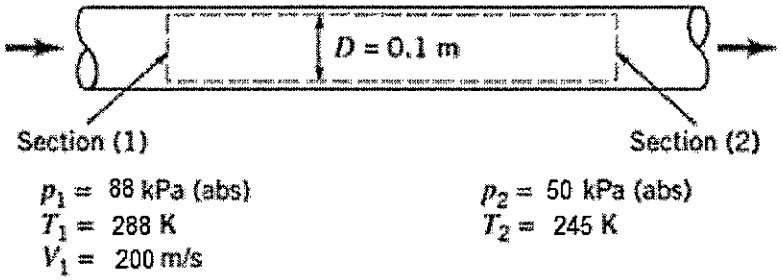


Figure Q2b

[9 marks]

Continued ...

Question 3 (25 marks)

(a) What is the Buckingham Pi theorem? Explain briefly how it is useful in fluid mechanics. [5 marks]

(b) Using dimensional analysis, show that the force resistance R to the motion of a hydroplane in water is of the form

$$R = \rho V^2 l^2 \, \phi(V^2/lg),$$

where ρ is the water density, V is the velocity, l is the length of the plane and g is the acceleration due to gravity. [14 marks]

(c) What is the name given to the dimensionless group (V^2/lg) in part (b)? This special dimensionless group represents the ratio of two types of forces influencing motion in a fluid. Define this force ratio and show how it leads to the group (V^2/lg). [6 marks]

Question 4 (25 marks)

(a) What are the two main types of turbo-machines? Briefly explain the similarity and difference between them. Give three more names of the devices for each type. [5 marks]

(b) A water turbine develops 150 kW of power and is rotating at 300 rpm (revolutions/minute) from available head of 15 m.

(i) If the turbine is run at a speed of 310 rpm, under the same head, what is the expected power, based on the similarity law? You may assume that the power coefficient is $[P/\rho D^5\omega^3]$, where P is the power, ρ is the fluid density, D is the diameter of the turbine impeller, and ω is the rotation speed.

(ii) If the turbine is run at 160 kW, under the same head, what is the percentage change in the speed? [12 marks]

(c) You are asked to design a similar turbine as that in (b), but a larger one that can accept a head of 18 m and runs at speed of 168.5 rpm. Using the head coefficient as a guide, what is the expected scale ratio of this new turbine? Take the head coefficient as $[D\omega/\sqrt{gH}]$, where g is the gravitational acceleration and H is the head. [8 marks]

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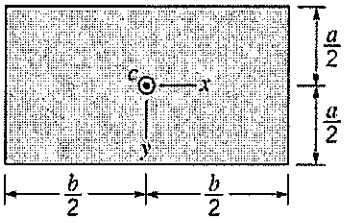
Appendix A

Geometric properties of some common shapes



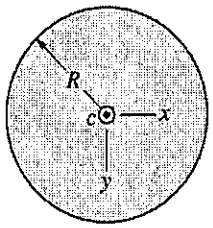
$A = ba$

$I_{xc} = \frac{1}{12}ba^3$

$I_{yc} = \frac{1}{12}ab^3$

$I_{xyc} = 0$

(*a*) Rectangle

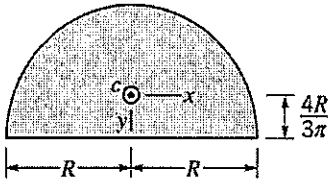


$A = \pi R^2$

$I_{xc} = I_{yc} = \frac{\pi R^4}{4}$

$I_{xyc} = 0$

(*b*) Circle



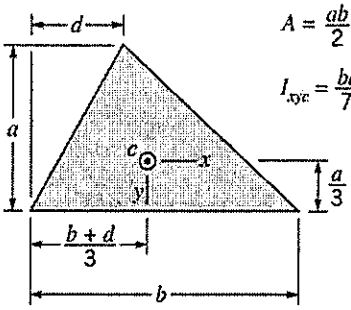
$A = \frac{\pi R^2}{2}$

$I_{xc} = 0.1098R^4$

$I_{yc} = 0.3927R^4$

$I_{xyc} = 0$

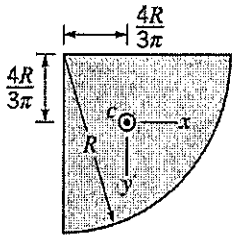
(*c*) Semicircle



$A = \frac{ab}{2}$ $I_{xc} = \frac{ba^3}{36}$

$I_{xyc} = \frac{ba^2}{72}(b - 2d)$

(*d*) Triangle



$A = \frac{\pi R^2}{4}$

$I_{xc} = I_{yc} = 0.05488R^4$

$I_{xyc} = -0.01647R^4$

(*e*) Quarter circle

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